AN ANALCITE-BEARING CAMPTONITE FROM NEW MEXICO.

DURING the summer of 1899 the writer was a member of the field class of Professor R. D. Salisbury, of the University of Chicago. The party visited the Grand Canyon of the Colorado, stopping on the way at several localities of interest. The first halt was made at Las Vegas, New Mexico, where Miss Inez Rice, a member of the class, guided the party to the butte which forms the subject of this paper. I take pleasure in acknowledging my indebtedness to Professor Salisbury for assistance in the field, and to Miss Rice for suggestions on the general geology of the region. The petrographic work was done in the laboratory of Columbia University, and thanks are due to Professor Kemp for much kindly advice and assistance. Special thanks are also due to Dr. F. Bascom and to Dr. H. S. Washington, for reading this paper and for suggestions concerning it. The analysis was very kindly contributed by Mr. George A. Goodell, of the College of Physcians and Surgeons; the photograph which forms the accompanying illustration (Fig. 1) was obtained through the courtesy of Mr. K. M. Chapman, of Las Vegas. Special thanks are due to both these gentlemen.

The Las Vegas region exhibits the general geology and physiography typical of the eastern border of the Rocky Mountains. In it are represented the two great geographical provinces, the Great Plains and the Cordilleran region. These two geographical districts are in close correspondence with the geological structure.

The Cordilleran section consists of a doubtfully Archean floor, upon the base-leveled surface of which Carboniferous limestones were deposited. This represents an overlap beyond the Cambrian which underlies the Carboniferous farther north. Unconformably above the Carboniferous, and situated along

the line bounding the two geographic regions, are the Red Beds of Permo-Triassic age, with their associated gypsum deposits. The relation of physiographic form to geologic structure is most excellently exhibited. The hard granitic rocks stand out as rugged peaks, with occasional gentle slopes where the Carboniferous limestones are left on their flanks. The Red Beds represent the softest rock of the region, and the position of this outcrop is marked by a valley.

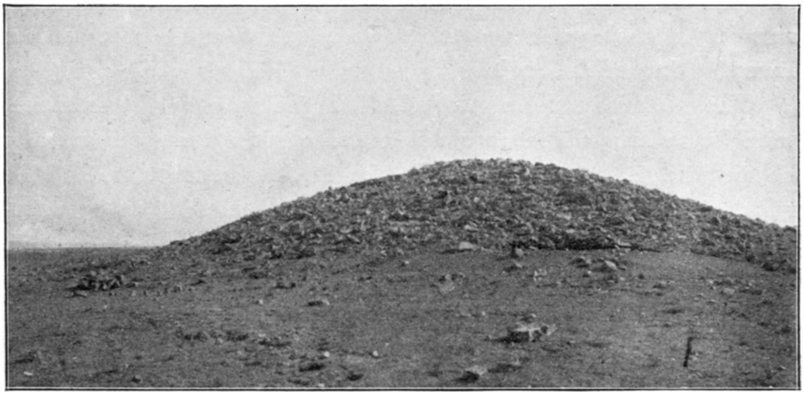

FIG. 1.—View of Camptonite butte, Las Vegas, New Mexico.

The contrast between the Cordilleran region and the Great Plains is both structural and physiographic. The latter region is underlaid by the Dakota and Colorado formations, with occasional remnants of the Montana and Laramie. Except near the mountains, the Cretaceous formations are nearly horizontal, but there they are upturned. Throughout Colorado and northern New Mexico, the outcrop of the Dakota sandstone forms a series of ridges locally known as "hog-backs." Las Vegas is situated at the eastern base of one of them.

About four miles slightly north of east of Las Vegas there is a little butte of igneous rock of exceptional interest. The structure of the rock and its occurrence indicate that it was intruded into the Cretaceous beds at a considerable depth, though it now stands somewhat above its surroundings.

The rock is probably to be referred to the group described by Professor Pirsson[1] as "the analcite group of igneous rocks," and no similar rock has hitherto been described from this region. Similar masses are mentioned in the Elmoro folio, and termed "lamprophyres," hence it is probable that future investigation will bring to light other related intrusions.. No elaeolite syenite nor other rock that could be related to these lamphrophyric intrusions has yet been found; hence the relationship of the rock and the magmatic history of the group to which it belongs, remain as problems to be studied in connection with the further investigation of the region.

The rock is medium grained, of a general gray appearance, with large crystals of hornblende and augite which can readily be seen with the naked eye. In the predominating phase of the rock, these crystals are about $.8^{mm}$ in length, but in occasional segregations they reach a length of as much as 1^{cm}. These ferro-magnesian minerals lie in a gray groundmass which on microscopical examination proves to be mostly plagioclase.

In thin section the rock is seen to be porphyritic, with phenocrysts of augite and of hornblende, occurring in equal amounts, and of rarer biotite. The groundmass consists of a network of plagioclase, with an isotropic substance which is probably analcite, filling the interstices between the plagioclase laths. Magnetite, ilmenite, and apatite are also present.

The pyroxene is always idiomorphic, occurring in large phenocrysts and also to a small degree in the groundmass. It is a pale greenish-violet, normal augite, and is very faintly pleochroic. The cleavage is well defined. Some of the porphyritic crystals show a slight zonal structure. Twinning is very common and usually the twinning plane is $\infty P\frac{1}{\infty}$ (100). Certain complicated intergrowths also occur, which probably also represent twinning, the twinning planes being $-P\frac{1}{\infty}$ (101) and P_2 (122) (Fig. 2).

[1] L. V. Pirsson, Jour. Geol., Vol. IV, 1896, pp. 679–690.

Intergrowths of augite and hornblende are common, and so are occasional inclusions of augite in hornblende (Fig. 3).

The amphibole is idiomorphic, occurring only as a phenocryst. It is of the basaltic hornblende type. The pleochroism is very strong, **c** and **b** = deep brown, **a** = pink. The terminal faces are usually lacking. These phenocrysts exhibit the characteristic cleavages of hornblende. In a few slides a very small amount of secondary hornblende was found associated with the augite, but the prevailing hornblende is certainly an original constituent.

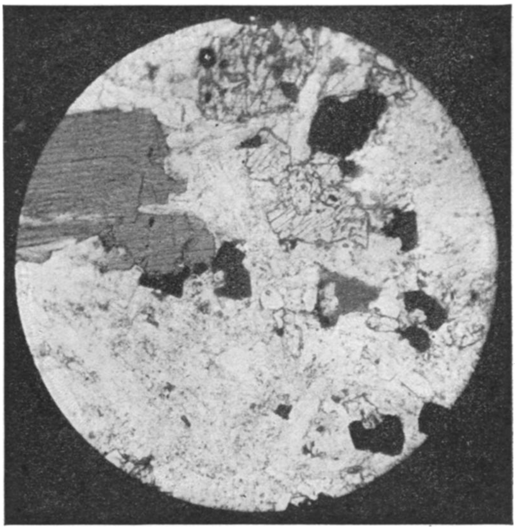

FIG. 2.—Twinned aggregate of augite.

Mica occurs in small quantity, as irregular shred-like phenocrysts. It is a very pleochroic biotite, changing from brownish-black to reddish-brown.

The feldspar occurs in the groundmass, as lath-shaped, polysynthetically twinned crystals. They form an interlocking network which is difficult of interpretation; a number of readings of extinction angles on the *P* face varied from 15° to 35°, indicating a plagioclase rich in lime (bytownite or anorthite). The presence of this plagioclase is further indicated by the high lime percentage of the analysis.

Lying between the laths of feldspar is an isotropic substance which appears to be analcite. It occurs in such small areas and is so thoroughly mixed with the groundmass that determinations of it were necessarily imperfect. In one instance it exhib-

ited the cubical cleavages of analcite. The rock was fresh and this mineral was undoubtedly of primary origin, being apparently the last to crystallize and filling all interstices. The larger grains are free from inclusions, but are sometimes surrounded by rings of magnetite and ilmenite grains; the smaller grains often contain a fine black dust suggestive of leucite. This structure appears to be identical with that described by Mr. Cross in the case of an analcite basalt.[1]

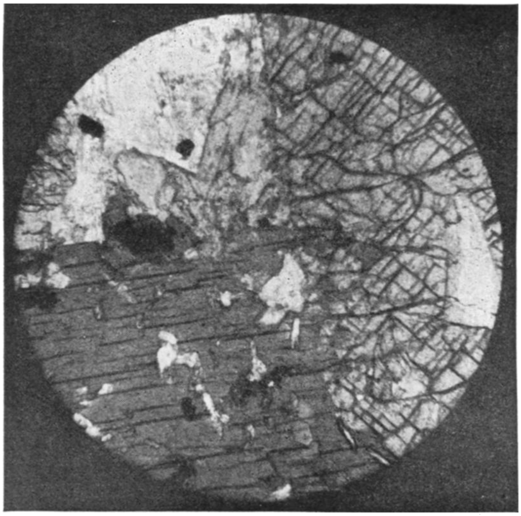

Fig. 3.—Intergrowth of hornblende and augite, with inclusions of augite in hornblende.

Magnetite and ilmenite are abundantly distributed in large crystals. Apatite occurs in the form of elongated prisms with truncated corners, and is common throughout the groundmass.

Very little alteration could be seen in any of the constituents. As already mentioned, very small amounts of secondary hornblende occur, derived from the augite. The plagioclase is occasionally slightly sausuritized, and small quantities of secondary epidote are occasionally found. The rock as a whole is, however, remarkably fresh.

The most noted district for rocks of this class is the neighborhood of Lake Champlain, where they have been made known principally through the work of Professor Kemp.[2] The writer

[1] Whitman Cross "An Analcite-basalt from Colorado," Jour. Geol., Vol. V, 1897.

[2] J. F. Kemp, "Trap Dikes of Lake Champlain," *Bull. 107, U. S. Geol. Surv.*

has compared the slides of the Las Vegas rock with those from the Champlain region, and also with those from Campton Falls,[1] from Whitehall and Fairhaven, Vt.,[2] and several neighboring localities; and with a series from the Black Forest in Germany. When all these camptonites were studied and compared with the Las Vegas rock, a marked difference in texture was seen. The Las Vegas rock is coarser grained, the phenocrysts more abundant, and there is a less marked difference in size between phenocrysts and groundmass. This is what might be expected since the eastern rocks occur in dikes, and the Las Vegas one in a stock. The eastern rocks are all considerably altered, containing calcite, serpentine, delessite, and secondary analcite. The Las Vegas rock is remarkably fresh. This comparison gives strong indirect evidence of the primary character and analcitic nature of the isotropic substance; the rock is too coarse-grained for it to be a glass and too fresh for it to be a secondary product.

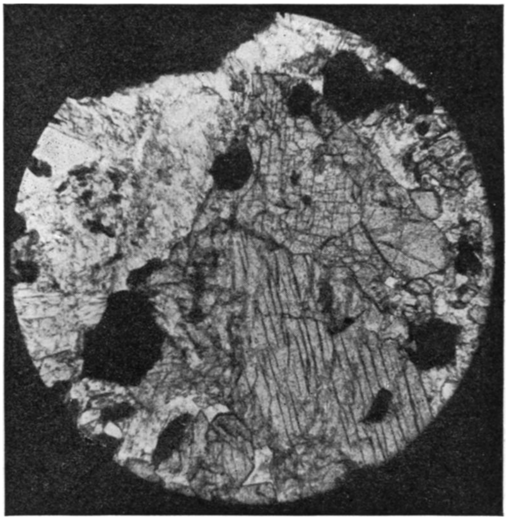

FIG. 4.—Typical section of the Las Vegas Camptonite, showing phenocrysts and groundmass.

The term "Camptonite" is commonly applied to the plagioclasic lamprophyres, in distinction from minette and vogesite which are orthoclasic. Common usage[3] has restricted the term Camptonite to the lamprophyric plagioclase rocks with horn-

[1] Described by J. W. HAWES, *Amer. Jour. Sci.*, ser. 3, Vol. XVII, p. 148.

[2] Described by J. F. KEMP, *Amer. Geol.*, Aug., 1889.

[3] F. BASCOM, *Nineteenth Ann. Rept. U. S. Geol. Surv.*, Part III.

ANALYSES.

	I.	II.	III.	IV.	V.	VI.
SiO_2	44.48	38.45	41.94	45.76	45.11	42.08
Al_2O_3	20.43	19.68	15.36	20.48	19.67	20.88
Fe_2O_0	9.72	4.01	3.27	1.99	4.32	6.77
FeO	2.18	11.15	9.89	4.18	8.57	3.17
CaO	10.35	9.37	9.47	11.57	10.45	12.48
MgO	5.51	6.65	5.01	8.50	5.65	6.85
TiO_2	.57	....	4.15	....	0.21	....
MnO	....	trace	0.25	....	....	....
K_2O	1.59	1.72	0.19	0.80	0.64	0.44
Na_2O	3.61	2.77	5.15	3.56	3.87	3.37
Loss on ignition....	3.21	....	3.29	2.80	....	....
H_2O	....	1.49	....	....	0.17	3.18
CO_2	....	4.82	....	....	....	....
P_2O_5	....	....	....	....	0.25	....
Total	101.65	100.11	100.44	99.64	100.07	99.22

I. The Las Vegas rock.

II. Camptonite from Campton Falls, N. H. Published in *Bull. 148, U. S. Geol. Survey*, p. 67.

III. Camptonite from Campton Falls, N. H. J. W. Hawes, *Am. Jour. Sci.* Ser. 3, Vol XVII, p. 150.

IV. Gabbro from Rosswein, Saxony. Landwirthsch Versuchs station 40, 1892.

V. Diorite from Lindenfels, Hesse Darmstadt. Chelies & Klemm, *Erläuterung zur Geologischen Karte von Hesse*, 1896.

VI. Basalt, middle flow, Carlsbad, Bohemia. *Jahrbuch der Königlich Kaiserlichen Gesellschaft Kunstaustellnng*, Vol. XL, p. 345, 1890.

blende as the principal ferro-magnesian mineral; augite camptonite is applied to those in which augite equals or exceeds hornblende; analcitite to those containing primary analcite. Rosenbusch's latest definition (1901) includes augite as an essential constituent of a camptonite, thereby departing from the original type of Hawes in which hornblende predominated.

In the case of the Las Vegas rock hornblende and augite occur in approximately equal quantities. Since the tests for analcite were not conclusive, the rock could not be called an analcitite. It seems most logical to regard equal amounts of hornblende and of augite as distinctive of a camptonite, restricting augite camptonite to those with augite in excess. The Las Vegas rock can thus most logically be termed an analcite bear-

ing camptonite. I am indebted to Dr. Bascom for suggestions on nomenclature.

The accurate recalculation of the analysis proved impossible, owing to the combination of minerals containing the same oxides. The high Na_2O is a strong indication that the isotropic constituent is analcite, and this is further indicated by the optical character of the plagioclase; it is near the anorthite end of the series, hence, has low Na_2O. Microscopically hornblende, augite, and plagioclase are present in approximately equal amounts.

Analyses two and three are typical camptonites, and it will readily be seen that the Las Vegas rock is close to them chemically. Analyses four, five and six are of rocks of other groups which are also similar chemically. The likeness of the last three was kindly suggested by Dr. Washington.

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